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Economic Impact of Environmental Regulations on the United States Copper Industry

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ECONOMIC IMPACT OF ENVIRONMENTAL REGULATIONS ON THE UNITED STATES COPPER INDUSTRY

SUMMARY

submitted to

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY

UNDER CONTRACT NO. 68-01-2842

JANUARY, 1978

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This report estimates, by use of an econometric model, the economic impact of environmental regulations on the United States Copper Industry. The report covers the principal air and water regulations as they affect copper mining, milling, smelting, and refining. Price, employment, production, and net imports are forecast over the period 1978-1987 both with and without present environmental regulations.

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SUMMARY

A. PURPOSE AND SCOPE

This study is one of a series commissioned by the United States Environmental Protection Agency to examine in detail the combined economic impact of environmental regulations on major industries[1]. Accordingly, the objective of this study is to assess the economic impact of federal environmental regulations on the domestic copper industry. The domestic copper industry is defined here to encompass the supply of primary refined copper and secondary copper, refined or unrefined, obtained from scrap. The supply of primary refined copper includes firms engaged in the production of copper from ore deposits, involving the mining, milling, smelting and refining stages of production. Downstream semifabricating and fabricating operations are not covered in this study.

This study addresses the economic impact of regulations which implement the following air and water pollution abatement and control legislation[2]:

- The Clean Air Act Amendments of 1970 and 1977; and
- Federal Water Pollution Control Act Amendments of 1972.

The following legislation or regulations have not been considered in this study because they are either still being written or because their language currently provides a wide latitude for interpretation by the various administrative agencies or the courts. The degree of uncertainty associated with these potential regulations is such that estimates of compliance costs cover an extremely wide range and suggest impacts varying from negligible to extremely high. These regulations are:

- EPA's new ambient or emission standards for elements such as lead and arsenic;
- Revised effluent limitation guidelines for toxic or priority pollutants;
- Limitations on non-point sources of aqueous effluents resulting, for example, from the Safe Drinking Water Act;
- The Resource Conservation and Recovery Act;
- Auxiliary regulations or administrative interpretations governing sampling methods for sulfur dioxide, lead, etc.;
- Federal and State land management and withdrawal regulations; and

- Mining Enforcement and Safety Administration (MESA) standards.

B. APPROACH

The objective of economic impact analysis of the type reported here is to identify and assess the effects of environmental regulations on such key economic variables as prices, output, employment and international trade, among others. It is also important to consider impacts on the industry's structure and on its international competitive position. Finally, it is necessary to identify potential plant closures and assess the resulting regional or community impacts.

Environmental regulations can affect an industry and generate economic impacts in a variety of ways. Compliance with the regulations typically requires the installation of pollution abatement and control equipment and associated process changes. The resulting compliance costs, by causing an upward shift in production costs, may ultimately lead to higher prices, reduced growth in output, substitution of other materials for copper and cause related economic impact. In addition, compliance costs may influence capacity expansion, for a number of reasons (e.g., reduced profitability, slower rate of growth in output, higher imports).

Further, the regulations may directly affect capacity growth by circumscribing in technical or legal detail the conditions under which existing capacity may or may not be modified (expanded) or the conditions under which new (greenfield) capacity may be built. Alternatively, the regulations, by virtue of their evolving nature, may increase the lead times and the costs associated with new projects and, cumulatively, create increased uncertainty. The resulting increase in the riskiness of new investments may slow down capacity expansion, either simply by discouraging new investment in the industry or by raising the minimum expected rate of return on invested capital.

Consequently, economic impacts may result not only because of compliance costs but also because of direct or indirect effects on capacity expansion. In the case of the domestic copper industry, the economic impacts result from a combination (confounding) of both compliance costs and capacity effects.

Economic impacts are typically measured as deviations from a set of baseline forecasts. Baseline forecasts are estimates of the values that all pertinent variables would take, over a period of time, in the absence of environmental regulations (or at least in substantial absence of environmental regulations). Under the assumption that the regulations are implemented, the same variables would take new values, over the same time period, because of increased costs of production due to compliance and because of the direct and indirect effects of the regulations on capacity growth. The differences between the two sets of results are attributed to the environmental regulations and define the economic impacts.

For impact analysis in this study, a computerized econometric simulation model of the United States copper industry has been developed and used. Figure 1 presents a simplified flow diagram of the structure of this model. The model is designed, estimated and programmed to simulate the industry's growth and evolution annually through 1987 under baseline conditions as well as under alternative policy scenarios. The model considers, within an interdependent framework, such variables as demand (paying attention to substitution from other materials such as aluminum), costs of production facing the producers, prices, investment and international trade. Costs of production are directly factored into the model through engineering cost functions so that technological developments as well as environmental factors affecting the industry can be readily assessed. Although the overall model specifically deals with both the primary producers and with the secondary copper industry (and the interaction between the two sectors), its major focus is on the primary producers. The model provides a unified analytical framework capturing quantitatively the pertinent interrelationships, to deal effectively with the measurement of impacts since environmental regulations set into motion an essentially simultaneous (interdependent) adjustment process in supply (costs), demand, prices and other variables.

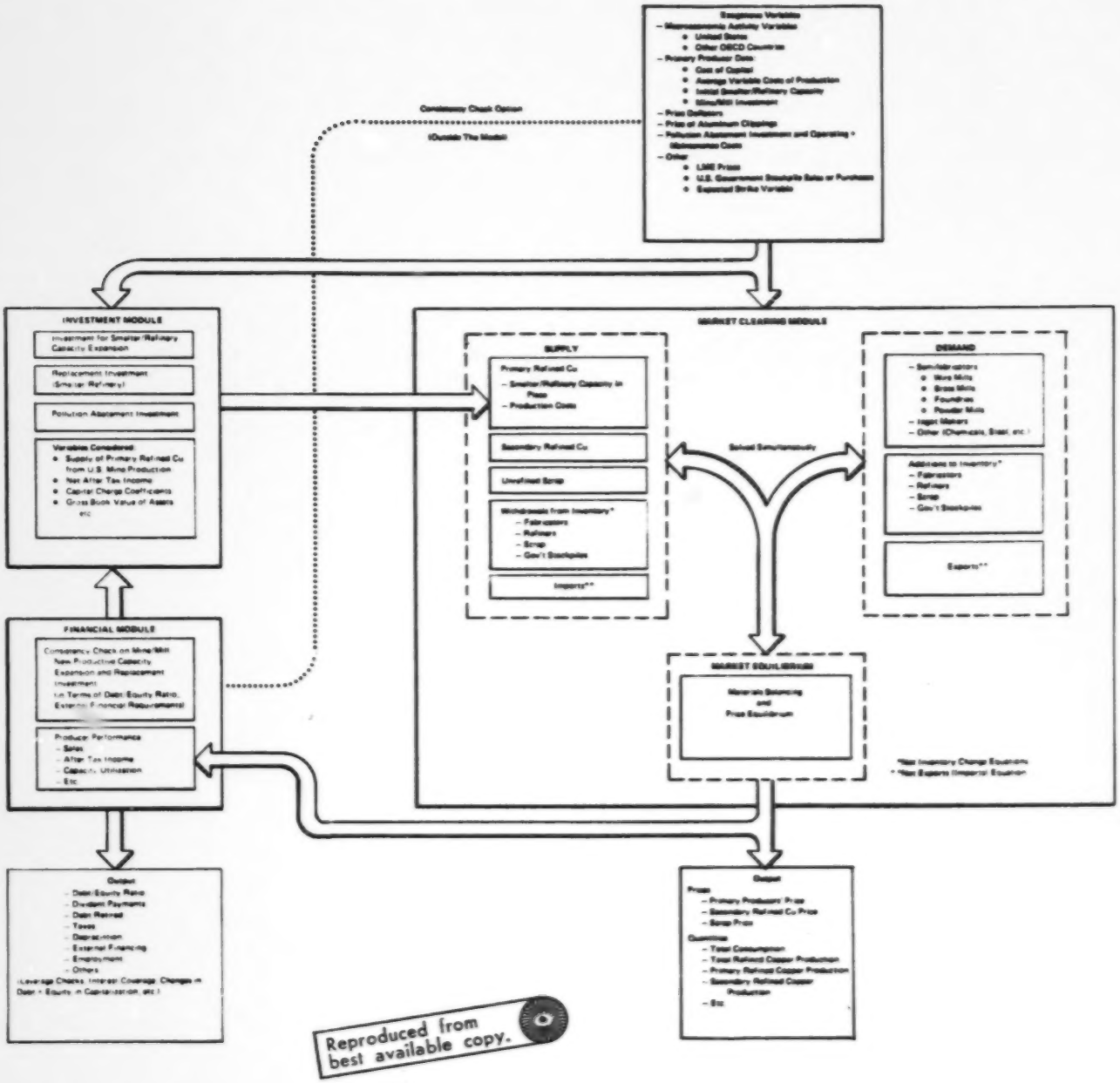
The model's output includes, among others, the following major variables which are jointly determined:

- total consumption of refined copper and its equivalent;
- changes in inventory stocks (additions, reductions) of primary producers, semifabricators, and secondary refiners;
- net international trade (net exports, net imports);
- production of primary refined copper by the domestic primary producers;
- production of secondary refined copper from scrap;
- production of scrap copper which is used directly;
- price of primary refined copper (domestic producers' price);
- price of secondary refined copper;
- price of copper scrap.

The model was used to develop annual forecasts over the period 1974-1987, which defines the impact analysis period, under baseline conditions as well as under alternative environmental scenarios.

FIGURE 1

SIMPLIFIED FLOW DIAGRAM OF THE ECONOMETRIC SIMULATION MODEL OF THE UNITED STATES COPPER INDUSTRY



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C. ENVIRONMENTAL REGULATIONS

1. Sources of Pollution

All four stages of primary copper production (mining, milling, smelting, and refining) are affected by Federal environmental regulations. Mining and milling are affected mainly by water and solid waste regulations, smelting by air regulations, and refining by water regulations. Of these, the air pollution control regulations for copper smelters are currently the most significant.

The conventional smelting of copper sulfide concentrates typically involves three steps: roasting, smelting and converting. Of these, the roasting step is optional. Roasted concentrates (calcines) or concentrates as received can be smelted in reverberatory furnaces (reverbs). The smelting process generates gas streams containing a large amount of sulfur dioxide at each process unit (i.e., roaster, reverb, or converter). In addition, the converting operation generates a small amount of sulfur dioxide which is very dilute and difficult to capture ("fugitives").

The distribution of sulfur among the gas streams emitted by these sources, expressed as percent of total sulfur contained in the concentrates entering the smelter, and the characteristics of these gas streams, are as follows:

Source	Emission Stream Characteristics	Sulfur distribution (% of sulfur contained in concentrates entering the smelter)	
		Calcine Smelting	Concentrate Smelting
Roaster	strong[3]-continuous	20	-
Reverb	weak[3]-continuous	25	40
Converter	strong[3]-intermittent	50	55
Fugitives	very weak[3]-intermittent	5	5

The predominant technique used to control emissions at a smelter is through the construction of sulfuric acid plants, whereby the sulfur dioxide (SO_2) is converted to sulfuric acid.

Sulfuric acid plants can utilize only the strong sulfur dioxide streams. Thus, the use of this conventional technique can capture about 50-70 percent of the sulfur in the smelter feed materials. The weak SO_2 stream from the reverb and the roasters, after suitable treatment for the removal of particulate matter, are emitted to the atmosphere using tall stacks. The fugitives are emitted close to the ground.

2. Air Pollution Control Regulations

The Clean Air Act Amendments of 1970 and 1977 establish four principles that are particularly relevant to air pollution control in copper smelting. They are the following:

- The Amendments require that National Ambient Air Quality Standards (NAAQS) be met at all times by the use of permanent emissions reduction technology. Intermittent control systems based on dispersion by any means, most notably by the use of tall smoke stacks, and production curtailment to reduce emissions under adverse meteorological conditions (i.e., Supplementary Control Systems or SCS) are not acceptable means of achieving ambient air quality standards. These requirements lead to the establishment of an "ultimate emissions limit", discussed below, which must be achieved no later than January 1, 1988.

- All new sources must use Best Available Control Technology (BACT) for permanent reduction of emissions. This requirement results in New Source Performance Standards (NSPS) for new sources or for reconstructed and modified existing sources.

- The Amendments require that smelting activity cannot lead to significant deterioration of existing air quality in regions which are cleaner than the ambient standards. For a particular location, these requirements define the extent to which new smelting activity can increase ambient concentrations of pollutants.

- In areas which have not attained ambient standards, the Amendments require that reasonable progress be made towards the achievement of National Ambient Air Quality Standards. This results in a series of preconditions which must be met before modifying an existing emissions source. Basically, total emissions after modification have to be lower than prior emissions (i.e., "emissions offsets") by using emission control technology capable of the "Lowest Achievable Emissions Rate" (LAER). Typically, existing smelters would be designated to be in nonattainment areas because they will not be achieving the ultimate emissions limit. Any modification of an existing smelter would therefore be subject to the requirements noted above and would have to be consistent with the attainment of the ultimate emissions limit by 1988.

As a result, copper smelters are potentially subject to several types of limitations on the emission of sulfur dioxide (SO_2) into the atmosphere. These emissions limitations differ in terms of their degree of stringency, method of calculation and applicability (i.e., whether they apply to the smelter as a whole or to individual pieces of equipment). They are the ultimate emissions limit, Lowest Achievable Emissions Rate (LAER), Best Available Control Technology (BACT) and Reasonably Available Control Technology (RACT). In addition, New Source Performance Standards (NSPS) apply to major pieces of process equipment.

For each smelter an ultimate emissions limitation is established at a level sufficient to ensure that NAAQS are met at all times without the use of dispersion techniques or production curtailment. This ultimate emissions limit, which is to be calculated assuming stack heights of two-and-one-half times building height or less for stacks built after 1970, is computed through the use of diffusion modeling and is dependent on the allowable stack height, the weather and topography in the vicinity of the smelter and smelter size. The ultimate emissions limit generally requires the capture of over 90 percent of the sulfur in the input (feed) materials entering the smelter.

The other emissions limits are technology-related and depend on the processing equipment used at a particular smelter. In increasing order of stringency, they are RACT, BACT and LAER.

- RACT is usually defined as control of all strong sulfur dioxide gases (approximately 4-5 percent SO_2) by a double absorption acid plant, if these gases were not being treated, or control by a single absorption plant if such a system were already being utilized. RACT at existing smelters can achieve 50-70 percent capture of the sulfur in the input (feed) materials.

- BACT and NSPS are usually the same. (NSPS can be less stringent than BACT because of delays in NSPS revision). NSPS require that gases from any new, reconstructed or modified smelting furnace, roaster or converter be treated in a pollution control system equivalent to a double absorption acid plant which removes 99.6 percent of the sulfur dioxide in the gas stream. BACT/NSPS applied to non-reverb smelting can achieve over 90 percent control.

- LAER could achieve additional pollution control beyond BACT via the control of fugitive emissions, weak gas scrubbing, etc.

Under the Clean Air Act Amendments of 1977 an existing smelter not meeting the ultimate emissions limit can continue to operate under a nonferrous smelter order (NSO). The NSO is essentially a five-year variance, renewable once, which allows a smelter to operate using Reasonably Available Control Technology (RACT) or as much control equipment as it can afford, together with tall stacks and SCS. Only those copper smelters that are technically or economically unable to meet the ultimate emissions limit for sulfur dioxide are eligible to operate under an NSO. Upon termination of the NSO, the smelter must either be achieving the ultimate emission limit or it must close down. As a condition of operating under an NSO, the smelter must install as much pollution control equipment as it can afford, must continue R&D on emissions reduction technology, and must achieve ambient air quality standards.

D. FINDINGS

1. Direct Impact of Pollution Control Regulations on Capacity Growth

The basic conclusion emerging from an analysis of the historical pattern of smelter capacity expansion is that the copper industry has traditionally preferred incremental expansion at existing sites, rather than the construction of new (greenfield) smelters. The lead time required for planning, engineering, construction, shake-down and start-up for small expansions at existing sites is about two-to-three years while that for new (greenfield) smelters is about five-to-seven years.

The presently promulgated environmental regulations, summarized above, affect capacity expansion of the domestic copper industry in the following fashion. First, they do not allow (or, effectively prohibit) small smelter expansions of the type used traditionally by the industry. Second, while there are some uncertainties, the regulations appear to allow the construction of NSPS caliber (or better) smelters in new locations and also in existing smelter locations. However, because of the lead time requirements, major new capacity of this type is not likely to come on-stream before 1985. Finally, the reverb based smelters will have to undergo major alterations to non-reverb technology by 1988 or they would have to shut down. Consequently, the currently promulgated environmental regulations will effectively constrain domestic capacity growth until 1985 and would require major expenditures for capacity maintenance between 1983 and 1988. In the interim, minor increases in capacity are expected for hydrometallurgical processing of oxides and expansion at non-reverb smelters.

The prospects for capacity expansion at the mining, milling and refining stages of production are not independent of the growth or contraction in smelting capacity. That is, smelting capacity essentially represents the "bottleneck" in primary refined copper production. Hence, the foregoing findings strongly suggest that the supply of refined copper domestically will be constrained over the next decade because of the constraints on domestic smelter capacity growth.

The domestic copper industry faces a variety of theoretically plausible paths for smelter capacity expansion, within the constraints or bounds circumscribed by the regulations, and subject also to economic constraints. These paths cover the following possibilities: (1) all existing smelters will be in compliance with the requirements of the 1977 Amendments by January 1, 1988; (2) some smelters will choose to shut down instead of complying with the ultimate emission requirements; (3) one or more greenfield smelters will come on-stream

during the period 1985-1987; (4) additional leach-electrowinning capacity will be brought on-stream during 1978-1987; and (5) four non-reverberatory smelters that are at or close to compliance with the New Source Performance Standards (Inspiration, Hidalgo, Anaconda, and Garfield) will be allowed to increase their capacity without installing incremental pollution control beyond NSPS.

Of the various permutations and combinations of these paths, two combinations have been selected as the most plausible for the purpose of economic impact analysis. These scenarios, labeled "Constrained Capacity" and "Reduced Capacity", are defined as follows:

- Constrained Capacity: This scenario assumes that none of the existing smelters will shut down; all smelters currently employing reverberatory furnaces will make progress towards compliance by January 1, 1988; that no new (greenfield) smelter capacity will be coming on-stream during this period; and that only marginal electrowinning capacity is expected to be introduced over the five-year period 1983-1987.

- Reduced Capacity: This scenario, which is the more severe in terms of capacity expansion, assumes that three smelters (Phelps Dodge-Douglas, Kennecott-McGill, and Asarco-Tacoma or an equivalent smelter) will close down in 1983, for various reasons. These three smelters have a combined capacity of 268,000 annual short tons of refined copper equivalent. As under the Constrained Capacity scenario, no new (greenfield) smelter capacity will be coming on-stream during this period, and only marginal electrowinning capacity is expected to be introduced during the five-year period 1983-1987.

2. Compliance Costs

Estimated pollution control capital expenditures, as well as operating and maintenance costs over the period 1974-1987, under the two basic environmental scenarios just described, are given in Table 1.

These estimates assume that there will be no fundamental change in the relative cost and nature of pollution control technology between now and 1988. The costs shown are for (1) the control of strong streams using acid plants, (2) the control of fugitive emissions by improved collection and the use of tall stacks for dispersal; and (3) the conversion of reverberatory smelters to non-reverberatory smelting by 1988.

TABLE 1

ESTIMATES OF POLLUTION ABATEMENT AND CONTROL EXPENDITURES
BY THE UNITED STATES COPPER INDUSTRY[a], 1974-1987
(In millions of 1974 dollars)

Year	CONSTRAINED CAPACITY					REDUCED CAPACITY				
	Capital Expenditures[b]			Operating and Maintenance Costs[e]	TOTAL	Capital Expenditures[b]			Operating and Maintenance Costs	TOTAL
	Non-reverberatory Related Capital Expenditures	Reverberatory Conversion Investment[c]	Total			Non-reverberatory Related Capital Expenditures	Reverberatory Conversion Investment[d]	Total		
1974	226.0	-	226.0	57.4	283.4	226.0	-	226.0	57.4	283.4
1975	240.8	-	240.8	49.3	290.1	240.8	-	240.8	49.3	290.1
1976	156.0	-	156.0	48.8	204.8	156.0	-	156.0	48.8	204.8
1977	90.0	-	90.0	42.3	132.3	90.0	-	90.0	42.3	132.3
1978	60.0	-	60.0	98.0	158.0	60.0	-	60.0	98.0	158.0
1979	40.0	-	40.0	88.2	128.2	40.0	-	40.0	88.2	128.2
1980	40.0	-	40.0	89.5	129.5	40.0	-	40.0	89.5	129.5
1981	40.0	-	40.0	89.8	129.8	40.0	-	40.0	89.8	129.8
1982	40.0	-	40.0	89.6	129.6	40.0	-	40.0	89.9	129.9
1983	40.0	156.5	196.5	90.0	286.5	40.0	126.7	166.7	78.6	245.3
1984	40.0	156.5	196.5	89.8	286.3	40.0	126.7	166.7	78.4	245.1
1985	40.0	156.5	196.6	90.1	286.6	40.0	126.7	166.7	78.5	245.2
1986	40.0	156.5	196.5	90.2	286.7	40.0	126.7	166.7	78.5	245.2
1987	-	156.5	196.5	90.0	246.5	-	126.7	126.7	78.4	205.1
1974-1987	1,092.8	782.5	1,875.3	1,103.0	2,978.3	1,092.8	633.5	1,726.3	1,045.6	2,771.9
1978-19[illegible]	380.0	782.5	1,162.5	905.2	2,067.7	380.0	633.5	1,013.5	847.8	1,861.3

NOTES: For all footnotes, refer to Table XII-2 in the report.

SOURCE: Arthur D. Little, Inc., estimates.

Arthur D Little Inc

The cumulative capital investment is estimated to range between $1.7 billion (under Reduced Capacity) and $1.9 billion (under Constrained Capacity) in 1974 dollars over the period 1974-1987. Cumulative direct operating and maintenance cost is estimated to range between $1.0 billion (Reduced Capacity) and $1.1 billion (Constrained Capacity) in 1974 dollars over the same period. Total cumulative spending by the industry for pollution control over this period, including both capital and direct operating costs, is hence estimated to range between $2.8 billion and $3.0 billion in 1974 dollars.

Four points should be noted. First, these estimates exclude the industry's spending for pollution control over the period 1970-1973. Cumulative capital investment for pollution control over this period is estimated at $402 million. Second, roughly one-third of the total estimated cumulative pollution control expenditures over the period 1974-1987 have already been incurred (through 1977). Third, cumulative investment for reverberatory conversion required under the Clean Air Act Amendments of 1977, estimated at $783 million (in 1974 dollars) accounts for over 60 percent of total capital expenditures over the 1978-1987 period under the two environmental scenarios. Fourth, the expenditure levels given here will not necessarily be sufficient for the smelters to meet the ultimate emissions limit in all cases.

3. Baseline Forecasts

Baseline forecasts provide a point of reference from which comparisons can be made in order to gauge the relative and absolute magnitude of the economic impacts. A given set of baseline forecasts represent a fairly reasonable approximation of a generally plausible future picture of the world which can be used as a benchmark for comparison. For economic impact analysis, emphasis is generally put not on absolute differences from baseline conditions but on relative (percentage) differences. To safeguard against any systematic bias in the measurement of impacts, many alternative sets of experimental baseline forecasts were developed under alternative macroeconomic growth and other assumptions before deciding upon the baseline forecasts shown in Table 2.

The macroeconomic growth scenario that is assumed generally reflects moderate and steady growth in overall economic activity in the United States. The European economies, meanwhile, are expected to follow a slightly slower recovery and growth path, lagging the United States.

The baseline forecasts assume the existence of National Ambient Air Quality Standards (NAAQS) but assume the absence of additional restrictions regarding how such standards might be achieved. This means, in other words, nominal industry compliance with NAAQS, through minimal permanent control and extensive use of SCS, but no constraints on

the modes of capacity growth. As a related matter, the baseline costs for new capacity assume that this capacity would be built with acid plants for controlling strong streams, but without other pollution control measures. Pollution control costs are hence treated as part of the cost of production.

The impact analysis period was defined as the 1974-1987 time span, where 1974, the base year in the analysis, is also the start of the impact analysis period. The year 1987 represents the terminal year of the second Nonferrous Smelter Order (NSO) period specified under the Clean Air Act Amendments of 1977.

4. Summary of Economic Impacts

The combined effects of both capacity constraints under the "Constrained Capacity" and "Reduced Capacity" scenarios and the associated pollution control expenditures result in the economic impacts tabulated in Table 2 and summarized below.

a. Impact on Prices

The price impacts of the presently promulgated environmental regulations reflect the combined influences of both compliance costs and constraints on capacity growth. Under Constrained Capacity, prices are 23.3 percent higher in 1985 and 29.4 percent higher in 1987 than those prevailing under baseline conditions. Under Reduced Capacity, real prices are higher than the baseline prices by 32.8 percent in 1985 and 38.7 percent in 1987. The forecasts of prices under the Constrained Capacity and Reduced Capacity scenarios should be interpreted as the price levels that would be expected to result from environmental regulations in the absence of a massive infusion of imports into the United States. Imports would be much higher if the rest-of-the-world (i.e., London Metal Exchange--LME) copper prices stay lower than the levels assumed under baseline conditions. The baseline conditions already show a persistent increase in the level of imports, a significant reversal of past trends.

b. Impact on Production

The impact on domestic primary refined copper production closely parallels the impact on copper prices, but in the opposite direction, resulting in a decrease in output. The full force of the production impact is felt in 1987, when domestic production falls 24.9 percent below the baseline forecast under Constrained Capacity and 32.9 percent under Reduced Capacity.

TABLE 2

ECONOMIC IMPACTS UNDER ALTERNATIVE ENVIRONMENTAL SCENARIOS AND CORRESPONDING COMPLIANCE COSTS ON THE UNITED STATES COPPER INDUSTRY, 1974-1987: SUMMARY OF SELECTED RESULTS

(all dollar figures in 1974 prices; quantities are in thousands of short tons)

IMPACT VARIABLE/SCENARIO	1974	1977	1979	1981	1983	1985	1987
Primary Refined Copper Prices							
Baseline	77.2	56.4	68.9	72.9	76.6	74.8	77.2
Constrained Capacity	77.3	59.4	73.5	80.5	88.7	92.2	99.9
Reduced Capacity	77.3	59.4	73.5	80.5	96.6	99.3	107.1
% Differences from Baseline							
Constrained Capacity	0.1	5.3	6.7	10.4	15.8	23.3	29.4
Reduced Capacity	0.1	5.3	6.7	10.4	26.1	32.8	38.7
Primary Refined Copper Production[a]							
Baseline	1792.7	2060.7	2191.6	2314.7	2477.5	2688.4	2897.3
Constrained Capacity	1790.6	1971.2	2039.6	2072.4	2095.6	2136.6	2175.5
Reduced Capacity	1790.6	1971.2	2039.6	2072.4	1867.3	1905.5	1943.0
% Difference from Baseline							
Constrained Capacity	-0.1	-4.3	-6.9	-10.5	-15.4	-20.5	-24.9
Reduced Capacity	-0.1	-4.3	-6.9	-10.5	-24.6	-29.1	-32.9
Net Imports[b]							
Baseline	167.1	239.6	274.3	361.5	356.0	513.8	571.2
Constrained Capacity	167.4	251.5	292.5	391.8	404.0	583.0	661.1
Reduced Capacity	167.4	251.5	292.5	391.8	435.2	611.2	689.6
% Differences from Baseline							
Constrained Capacity	0.2	4.9	6.6	8.4	13.5	13.5	15.7
Reduced Capacity	0.2	4.9	6.6	8.4	22.2	18.9	20.7
Total Consumption[c]							
Baseline	3397.8	3455.1	3792.4	4027.3	4221.8	4567.9	4864.3
Constrained Capacity	3396.9	3405.9	3708.6	3899.7	4019.3	4274.1	4474.1
Reduced Capacity	3396.9	3405.9	3708.6	3899.7	3917.0	4147.2	4345.2
% Differences from Baseline							
Constrained Capacity	-0.02	-1.4	-2.2	-3.2	-4.8	-6.4	-8.0
Reduced Capacity	-0.02	-1.4	-2.2	-3.2	-7.2	-9.2	-10.7
Employment[d]							
Baseline	62,953	58,051	64,886	68,530	73,350	79,595	85,780
Constrained Capacity	62,879	55,530	60,386	61,357	62,044	63,258	64,410
Reduced Capacity	62,879	55,530	60,386	61,357	55,285	56,416	57,526
% Differences from Baseline							
Constrained Capacity	-0.1	-4.3	-6.9	-10.5	-15.4	-20.5	-24.9
Reduced Capacity	-0.1	-4.3	-6.9	-10.5	-24.6	-29.1	-32.9

NOTES: [a] Domestic production of refined copper by primary producers, from all sources (domestically mined copper, imported ore/concentrate/blister/scrap, domestically generated unalloyed scrap); although it contains some secondary refined copper, it is exclusive of secondary refined output produced by secondary refiners.

[b] Net of exports.

[c] Includes primary and secondary refined copper, directly consumed scrap and imports.

[d] Total full-time equivalent employment (number of persons) including mining and milling, smelting and refining employment at all domestic primary producers facilities; employment by secondary smelters/refiners are excluded.

SOURCE: COPMOD I (i.e., the acronym used for the Econometric Simulation and Impact Analysis Model of the U.S. Copper Industry developed as part of this project; refer to Chapter XI for a general description and to the Technical Appendix accompanying this volume for a detailed description of this model).

c. Impact on International Trade

The overall pattern emerging from the model forecasts under baseline conditions is that net imports show a persistent increase over time, which represent a reversal of past trends. Under Constrained Capacity, net imports in the 1980s are generally 13-15 percent above baseline levels. Under Reduced Capacity, net imports become 20.7 percent higher than the baseline level by 1987. Again, imports would be much higher if the LME copper prices continue to remain depressed.

d. Impact on Consumption

The drop in total consumption below baseline levels is expected to reach 8.0 percent under Constrained Capacity and 10.7 percent under Reduced Capacity by 1987. The drop in total consumption is not as large as in domestic refined copper production, since demand for copper remains relatively inelastic and consumers make greater use of secondary refined copper, scrap, and imports, while restraining their consumption somewhat because of higher prices.

e. Impact on Employment

The impact on industry-wide employment at all stages of production (mining through refining), under both the Constrained Capacity and the Reduced Capacity scenarios, is expected to be felt sharply in terms of curtailing employment growth that would otherwise be expected to occur under baseline conditions. Basically, under the particular baseline forecasts used, Constrained Capacity would prevent about 21,000 full-time equivalent jobs and Reduced Capacity nearly 28,000 jobs by 1987, which respectively represent 24.9 percent and 32.9 percent less employment than under baseline conditions. It should be noted that no significant compensating employment growth in the secondary copper industry is expected. Likewise, employment growth at smelters due to pollution abatement would be relatively small.

The employment impacts under Constrained Capacity do not reflect layoffs but represent lower potential growth in a few Western states (e.g., Arizona, Utah, New Mexico, Montana, Nevada) where domestic copper mining, milling, and smelting operations are largely concentrated. The employment impacts under Reduced Capacity, with the exception of potential layoffs at the three smelters assumed to close down under this scenario (Kennecott-McGill, Phelps Dodge-Douglas, and Asarco-Tacoma or an equivalent smelter), would also basically reflect foregone employment growth.

f. Community Impacts

If Kennecott-McGill (Nevada) and Phelps Dodge-Douglas (Arizona) smelters actually do close down, as hypothesized under the Reduced Capacity Scenario, the impact on these two isolated communities would be severe. If, similarly, Asarco-Tacoma is closed down, as further hypothesized under the Reduced Capacity Scenario, the local impact would be quite significant.

These three smelters together employ about 3,100 persons (McGill, 1,480; Douglas, 610; Tacoma, 1,000). The McGill smelter is virtually the only source of employment in that community and accounts for over half the jobs in White Pine County, which contains McGill. Similarly, the Douglas smelter is a major employer, providing about 15 percent of total jobs in that community. Finally, the Tacoma smelter has remained, over many decades, a significant source of employment in Tacoma, even though the smelter currently contributes just over one percent of all jobs in Greater Tacoma (Pierce County).

g. Additional Impacts

These main economic impact results are supplemented by the following related findings:

- Smelter capacity utilization rates will remain extremely high during the next ten years, becoming progressively higher under the Constrained Capacity and Reduced Capacity Scenarios.

- Not much relief in the form of significantly increased supply of secondary copper is expected over the next ten years under either environmental scenario. Secondary copper prices, however, rise above baseline levels; by 1987 scrap copper prices will rise by as much as 27.0 percent above baseline forecasts under Constrained Capacity and 35.4 percent under Reduced Capacity, in view of the constraint on domestic smelter capacity growth and the relatively inelastic supply of secondary copper. Meanwhile the demand for copper is expected to shift upward secularly with the rise in industrial and investment activity.

h. Sensitivity Analysis

A sensitivity analysis was conducted to see how the impact results reported above might change under a somewhat different specification of the environmental/industry capacity growth scenarios. Specifically, the Constrained Capacity and Reduced Capacity scenarios were modified, by assuming alternative modes of smelter capacity expansion (including new smelters) and correspondingly introducing new estimates of compliance costs. Five different tests were performed. An examination of the sensitivity analysis results generally indicates that the severity of the impacts reported earlier, falling especially over the period

1983-1987, would remain broadly unchanged. Overall, the impacts are lessened when new capacity is assumed to come on-stream during this period under the various sensitivity tests. Everything considered, the lowest deviations from the baseline results appear to be those associated with a modified version of the Constrained Capacity scenario, which allows for new smelters to come on-stream in 1985 and 1987.

The baseline forecasts underlying the impact analysis and sensitivity tests reported above assume steady economic growth both in the United States and in other industrial countries. They further assume a gradual improvement in LME copper prices, in line with the expected macroeconomic growth conditions worldwide, along with expected costs of production abroad as well as expected mine capacity expansion in key copper exporting countries. However, worldwide economic recovery and growth might continue to be quite slow, and the LME copper prices might continue to remain at relatively low levels (i.e., significantly below assumed baseline levels). Then an unavoidable consequence of such a development would be a substantial rise in imports into the United States, low domestic copper prices resulting from increased foreign competition and a relatively depressed domestic copper industry. Under such circumstances, the impact of the environmental regulations on the domestic copper industry could prove extremely serious.

5. Broader Implications of Environmental Regulations and Related Issues

The environmental regulations and the impact results discussed earlier have broader implications and raise certain issues which deserve emphasis. These pertain to the regulatory environment, the growth of the domestic copper industry and the international economic implications.

a. Regulatory Environment

Environmental regulations not only lead to increased production costs due to the cost of compliance, but also cause uncertainty because of their evolving nature. For the copper industry, a major source of uncertainty in the future relates to the fugitive emissions problem (i.e., the magnitude of the fugitive emissions, the degree to which they might contribute to the violation of ambient standards even in the vicinity of smelters using modern, "exemplary" technology and the means which might be used to alleviate this problem). From a planning standpoint, the problem of uncertainty would increase the degree of risk associated with a new project, thus making the industry more cautious and increasing both the lead times and the costs required for adding new capacity. This, combined with the cumulative and sometimes conflicting nature of the regulations, may further create a broader set of unintended consequences, for example, by effectively curtailing expansion of domestic productive capacity. Moreover, the existence

of many regulatory agencies affecting a given industry, with little or no coordination among them (in the apparent absence of any legal requirement for them to coordinate their activities), may well compound the unintended and unforeseen effects of their actions. The situation may get more complex in the future if the present pattern of regulation of industry by Federal Government agencies continues.

b. General Issues Pertaining to the Future of the Domestic Copper Industry

The following general conclusions are suggested from the foregoing discussion and findings:

- Growth of the domestic copper industry: The constraint on domestic smelter capacity growth imposed by the presently promulgated federal environmental regulations, the continuing future uncertainty regarding new regulations and the way they will be enforced will quite likely slow down domestic smelter capacity expansion and new resource development generally.

- Technological and energy implications: The federal regulations affecting the copper industry in part represent an apparent desire to force technological change away from reverb-based technology towards new smelting technology more amenable to sulfur dioxide emissions control via the use of sulfuric acid plants. Although this new smelting technology is more energy efficient than reverb-based technology as far as smelting is concerned, the higher degree of pollution control offsets this advantage.

- The threat of substitution from aluminum: Aluminum prices could increase relative to copper prices, because of the actions of the major bauxite producing countries (e.g., increased taxes, cartelization, etc.) or because of higher energy costs. This may slow down the substitution of aluminum for copper but not necessarily stop it, especially because domestic copper prices would also rise because of compliance costs and constraints on domestic capacity growth.

c. International Economic Implications

The capacity constraints and costs of compliance resulting from environmental regulations may have significant international economic implications beyond those noted above pertaining to international trade effects. These can be summarized as follows:

- Effects on the international competitive position of the domestic copper industry: While the foregoing findings suggest that the international competitive position of the domestic copper industry will deteriorate, there may be mitigating factors which may also increase the costs of foreign production. Among these factors can be cited differential impacts of energy price increases, expected high rates of inflation not offset by exchange rate adjustments, high infrastructure investment requirements, generally lower labor productivity, and a growing set of requirements by international financing institutions (e.g., the World Bank) for pollution control at new projects.

- Effects on the international investment behavior of the domestic copper producers: Industry sources state that differences among various countries in terms of pollution control costs alone are likely to prove quite insignificant, in their decisions regarding new investments abroad, compared with the large number of uncertain factors associated with foreign investment in most developing countries. Further, while political risks abroad are generally assigned greater weight than environmental risks faced at home, there is a growing climate of opinion that political risks abroad are controllable through international financing, joint ventures, majority ownership in the host country, and other means. Accordingly, there appears to be emerging the perception that the cycle of expropriation abroad is at an end, whereas the end of environmental regulations in the United States is nowhere in sight. Hence, new investment is likely to be exported abroad to areas which are considered less risky politically. The recent growth in copper production capacity in Canada takes on new significance when viewed in this light. The Canadian copper industry, which will be a major beneficiary of the capacity constraint in the United States, is expected to emerge as a major exporter of copper to the United States.

- Implications for the structure of the copper industry: During the postwar period, the copper industry progressively became geographically more diverse worldwide and less concentrated. The capacity constraints emanating from environmental regulations domestically and the poor economic conditions facing the industry internationally are likely to slow down or delay the entry of new firms. This, combined with the recent emergence of CIPEC, may reverse the postwar trend.

- Implications for cartelization and international commodity agreements: CIPEC, patterned after OPEC, the oil "cartel", has yet to evolve a mechanism to control prices or, far short of that, to stabilize prices through an international buffer stock arrangement.

In the normal course of events in the future, the likelihood of the emergence of a CIPEC cartel would not appear to be high. Nevertheless, the likelihood that an expanded CIPEC will be able to exercise some influence or even control over the world price of copper in the medium-term future cannot be ruled out. Such a development could occur especially in the event of strong worldwide economic recovery, and might be aided, to some degree, by the constraint on smelter capacity growth in the United States. Strong worldwide economic recovery and growth would help improve the payments deficits of the CIPEC member countries and would, hence, ease the pressure on them for competitive pricing among themselves to obtain badly needed foreign exchange. In the longer-run, however, CIPEC would not appear likely to influence the course of world copper prices. Collusive control of copper prices, at higher disequilibrium prices, would soon invite increased primary copper supply from non-CIPEC sources, bring about some increase in the supply of secondary copper and hasten the substitution of other materials for copper. This would readily undermine efforts at collusive control of world copper prices over the long-run. Hence, for CIPEC, the ability to influence prices over a relatively short period would have to be weighed against longer-term earnings, in view of the generally self-correcting forces quite strongly present in the world copper market.

E. OVERVIEW OF THE COPPER INDUSTRY

1. Introduction

The United States is the leading producer and consumer of copper in the world, accounting for about one-fifth of total world refined copper production, consumption and reserves. Except for certain periods in the past coinciding with military developments or unusually high rates of economic growth, the United States has been nearly self-sufficient in copper. In the past two years, however, imports of foreign refined copper have increased significantly, reaching 21 percent of total domestic refined copper consumption in 1976 and roughly 25 percent in 1977.

With their sales from refined copper at about $2.5-3.0 billion, the domestic primary copper producers employ over 60,000 people in mining through refining, concentrated in such key copper producing states as Arizona, Utah, New Mexico, Montana and Nevada.

2. Sources of Copper and Production Technology

There are three major sources of copper: sulfide copper ores, oxide copper ores and scrap. Of these, the sulfide resources are the most important and we expect them to continue to play a dominant role in meeting demand in the foreseeable future.

Production of refined copper in the United States from all sources is shown in Figure 2. Domestically mined copper accounts for a major share of the total copper supply stream. In addition, copper recovered from scrap represents an important source of copper.

The production of primary (mined) copper is based mainly on the exploitation of low grade sulfide mineral deposits on a large scale and involves four stages of processing:

- mining--where ore containing approximately 0.4-2 percent copper is mined;
- beneficiation (or milling)--where the copper-containing minerals are separated from waste rock to produce a concentrate containing about 25 percent copper;
- smelting--where concentrates that contain about 25 percent copper are smelted to produce "blister" copper of 98 percent purity;
- refining--where blister copper is refined electrolytically to produce cathode copper of 99.9 percent purity. Subsequently, cathode copper is melted and cast into various shapes for fabrication.

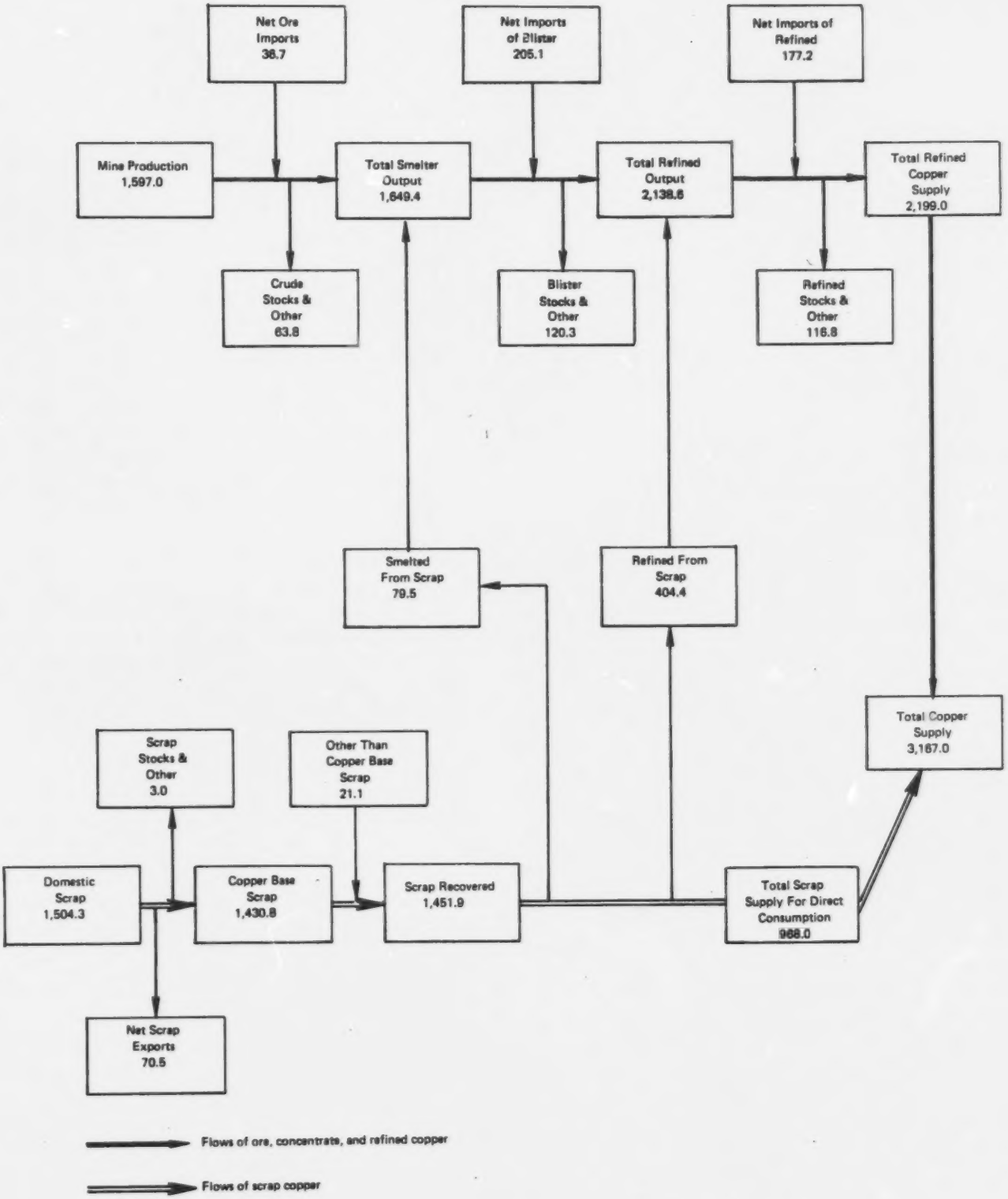
About 98 percent of the domestic mine production of copper comes from ores mined primarily for their copper content, the remainder is recovered from complex or mixed base-metal ores. The copper ores also are the source of significant quantities of by-products and co-products such as gold, silver, molybdenum, nickel, platinum, selenium, tellurium, palladium, arsenic, rhenium, iron, lead, zinc, and sulfur.

To minimize transportation costs, mills are almost always located close to the mines. The value of the concentrates is high enough to allow some flexibility in smelter location. Still, most smelters are located near the mills which supply them or on tide water or rail head in order to receive concentrates from distant mills. Refineries can be located anywhere between smelters and fabricators, since the transportation costs for blister and refined copper are about the same.

Most of the domestically mined copper is produced in five western states--Arizona, Utah, New Mexico, Montana, and Nevada. Over 80 percent of total United States mine production is located in Arizona, Utah and New Mexico taken together. Arizona alone accounts for well over half the total United States mine production of recoverable copper (about 63 percent in 1976). As shown in Figure 3, the copper smelters and refineries are also concentrated in the western states.

COPPER PRODUCTION SYSTEM IN THE UNITED STATES, 1974
(Thousands of Short Tons of Copper Content)

FIGURE 2


Net Ore Imports 38.7
Net Imports of Blister 205.1
Net Imports of Refined 177.2
Mine Production 1,597.0
Total Smelter Output 1,649.4
Total Refined Output 2,138.6
Total Refined Copper Supply 2,199.0
Crude Stocks & Other 63.8
Blister Stocks & Other 120.3
Refined Stocks & Other 116.8
Smelted From Scrap 79.5
Refined From Scrap 404.4
Total Copper Supply 3,167.0
Scrap Stocks & Other 3.0
Other Than Copper Base Scrap 21.1
Domestic Scrap 1,504.3
Copper Base Scrap 1,430.8
Scrap Recovered 1,451.9
Total Scrap Supply For Direct Consumption 968.0
Net Scrap Exports 70.5
Flows of ore, concentrate, and refined copper
Flows of scrap copper

Source: Compiled from Copper Development Association, Inc., *Copper Supply and Consumption, 1957–1975*, Tables 1 and 2.

Arthur D Little, Inc

Source: Arthur D. Little, Inc., (1977)

FIGURE 3: **LOCATION OF PRIMARY COPPER SMELTERS AND REFINERIES**

Different waste streams are generated during copper production. Large quantities of solid wastes (and in some cases, water effluents) are produced during mining and milling. However, in terms of complexity and cost, the air pollution problems of the smelters are currently the most important. In the United States, pollution control technology applied to standard reverberatory smelters can generally capture only about 50-70 percent of the sulfur in a smelter's feed materials through the manufacture of sulfuric acid. The use of new pyrometallurgical (state-of-the-art) technology would increase sulfur capture to over 90 percent. Even then, a typical smelter would generate 20 to 50 tons/day in the form of sulfur dioxide (SO_2) emissions. By contrast, EPA defines a major source as one that emits over 100 tons/year.

3. The Domestic Copper Industry in World Perspective

The United States, despite its declining share of total world consumption and production, still accounts for 24 percent of total world consumption and production, and over 18 percent of total world mine output (22 percent of world refined copper output).

In terms of its market structure, the domestic copper industry consists of the "primary" and the "outside" market sectors. The primary sector comprises firms which sell the bulk of their refined copper output (mostly from mined copper but also including some refined from scrap) on the basis of a commonly-followed domestic producers' price. The "outside" market, on the other hand, includes firms (e.g., merchants, scrap dealers and secondary refiners), which sell their copper output on the basis of one of several "outside" market prices.

The primary sector consists principally of the following firms: Kennecott, Phelps Dodge, Anaconda/ARCO, Magma/Newmont, Duval/Pennzoil, Cyprus, Asarco, Copper Range/Louisiana Land and Exploration, Inspiration, Cities Service, Ranchers Exploration, Hecla (in partnership with El Paso Natural Gas Company) and others. These firms are vertically integrated to different degrees from mining to refining and beyond into semifabrication. Several of the major copper producers are also major producers of other metals, such as lead and zinc, and others are aluminum producers. A number of producers participate jointly in foreign copper mining companies, notably in Canada, Africa, and South America.

The domestic copper industry has undergone important structural changes during the postwar period, with the entry of new firms at various stages of production, shifts in the degree of integration of firms, and important changes in ownership patterns (e.g., acquisision of copper companies by oil companies). As a result, the industry has become more diverse and somewhat less concentrated. In addition, the industry has become more complex or interdependent in terms of domestic or foreign joint-investments and buyer-seller relationships (e.g., custom/toll smelting and refining arrangements).

Internationally, copper output is highly concentrated in a relatively few countries. Along with the United States--still the largest single producer--five other countries (Canada, Chile, Zaire, Zambia, U.S.S.R.) together account for 71.2 percent of total world mine output in 1974.

There is considerable international trade in copper in all forms: ores, concentrates, blister, refined and fabricated products. The bulk of the world's copper exports is from the developing countries to Europe, Japan and the United States, with smaller amounts from Canada, South Africa and Australia. Japan and other industrial countries in Western Europe are heavily or even entirely dependent on external sources of primary copper.

During the postwar period, the copper industry has become not only more diversified geographically worldwide but also less concentrated as new firms have entered the industry. However, an opposite trend towards the nationalization of copper mining and processing operations in major copper exporting countries has brought about a significant shift in ownership patterns in the world copper industry in recent years. Chile, Zambia, Peru and Zaire formed in 1968 the Conseil Intergouvernemental des Pays Exportateurs de Cuivre (CIPEC), also known as the Intergovernmental Council of Copper Exporting Countries, which is patterned after OPEC, the oil cartel. These four original CIPEC countries together account for about 37 percent of Free World mine production in copper. With recent additions to its membership, CIPEC's share of internationally traded copper has increased to more than 70 percent.

4. Supply, Demand, Prices and Financial Performance

a. Supply

Copper reserves in the United States, mostly in the form of sulfide deposits, have been estimated at about 90 million short tons of copper (metal content), with an additional 320 million short tons in the form of "other" deposits, including undiscovered (hypothetical and speculative) deposits. The United States accounts for about 20 percent of known world copper reserves and other copper resources. Five states--Arizona, Utah, New Mexico, Montana, and Michigan--account for more than 90 percent of the total domestic reserves. The average ore grade of the domestic reserves held by such major producers as Kennecott, Phelps Dodge, Anaconda and Magma range in the neighborhood of 0.70-0.80 percent, the ore grade at some currently producing mines falls well below this range.

We expect sulfide reserves to continue to play a dominant role in meeting growing demand in the foreseeable future. In contrast with sulfide reserves, the oxide reserves are quite small and represent a far less important source of primary copper.

Although the bulk of domestic copper supply originates from primary or mined copper, secondary copper recovered from scrap also represents a significant source of copper supply, accounting for over 40 percent of domestic copper consumption. Copper obtained from scrap enters the supply stream in two forms: as refined copper, in which case it becomes indistinguishable from primary refined copper, and in the form of scrap, which is used directly. Although the supply of secondary copper is inelastic, it is not completely unresponsive to changes in price.

The supply of copper from the available reserves is characterized by long adjustment periods. Typically, investments are large, have long productive life-expectancy, and are perceived to be highly risky in view of cyclical fluctuations in copper prices. Because of the cyclicality of the copper industry, the threat of long-run substitution from other materials, competition from both the secondary and foreign producers plus other factors, investments are made with an expected long-run target rate of return. This defines the industry's "incentive price", that is, the price at which the firms would be willing to stay in business over the long-run, where revenues are sufficient to cover full costs, including a return on investment high enough to attract new capital. Hence, the long-run price of copper would tend to equal the long-run economic cost of copper (i.e., the price sufficient to induce continued investment at all stages of production).

The domestic copper industry is believed to have experienced sharp increases in production costs in recent years because of a combination of factors including declining ore grades, stagnant productivity, and steep rises in energy and other factor costs, and pollution control costs. Costs of mining and concentrating have traditionally formed, by far, the largest proportion of total production costs of refined copper. Smelting and refining costs have represented only a small proportion of the total cost, with smelters and refineries functioning mainly as "service" operations on fixed and relatively low profit margins.

During the postwar period, domestic smelter capacity growth has occurred mainly through incremental additions to existing smelter operations, rather than the construction of new "grassroots" (or greenfield) smelters. This growth in capacity was achieved by improved beneficiation techniques which increased the copper content of concentrates and also because of improvements in reverberatory smelting technology.

b. Demand

Demand for copper is a derived demand, since it is used as an intermediate input in the production of final goods which are ultimately demanded for consumption. In 1974, wire mills, which use only refined copper, accounted for 47 percent of total copper consumption. Brass mills, which consume refined copper and scrap in fairly equal proportions, accounted for about 39 percent of total consumption. Ingot makers, who use almost

entirely scrap, were the third largest consumers at 7 percent. Foundries, consuming predominantly scrap, used about 4 percent, with powder plants, and "other industries" accounting for the remainder.

The major end-use industries consuming semifabricated goods are electrical and electronics products, building construction, consumer and general products, industrial machinery and equipment, transportation, and ordnance and accessories. Of these, the largest use of copper is in electrical equipment and supplies.

It is generally agreed that aluminum has been the most serious competitor to copper. The greatest replacement of copper has been in the power wire and cable sector, where some 40 percent of insulated power cable and over 90 percent of bare conductor applications are now provided by aluminum. Copper and aluminum are also mutually interchangeable in some heat exchanger applications.

Available econometric studies of demand for copper, including our own, generally indicate that in the short-run demand is quite inelastic with respect to both price and activity variables. The long-run elasticity estimates are all greater than the short-run estimates, indicating that the response of demand to relative prices and activity is more sensitive in the long-run. However, even the long-run estimates have been found in about half of the studies examined to fall in the inelastic range.

c. Prices

Historically, copper has been marketed at prices based on a number of different systems, some of them quite complex. Nevertheless, two basic pricing systems can be distinguished, the producer prices and prices related to quotations on metal/commodity exchanges.

Producer prices refer to prices established independently by the major primary producers. In the United States, the domestic producers' price is a set of nearly uniform price quotations used by the major domestic primary producers for a good part of the postwar period and by Noranda, one of the Canadian producers, for sales of primary refined copper in the United States. During the postwar period, about 75 percent of all refined copper production in the United States has been sold at the domestic producers' prices.

Copper is sold internationally (outside North America) by most producers most of the time, at prices related through various formulas to quotations on a metal/commodity exchange, principally the London Metal Exchange (LME). The LME and the New York Commodity Exchange (COMEX) are two organized metal exchanges (markets). Of the two, the LME is generally considered to be the more important in terms of turnover, physical deliveries, and its influence on the pricing of copper in general. Most of the "formulas" for pricing copper that are found on long-term contracts are related, in one way or another, to LME prices, since LME prices are generally

considered to reflect, without delay, changes in the supply and demand situation worldwide. It is important to emphasize that the LME and COMEX are basically hedge and speculative markets, rather than physical markets.

In the United States the label "outside market" is used to denote all trade in copper, apart from sales made at the producer price by the primary producers. Thus, the "outside market" includes the secondary industry (including scrap dealers and secondary refiners), some of the smaller domestic producers of primary copper and transactions in physical copper on the LME and COMEX plus imports based on LME quotations.

Demand for copper is quite inelastic in the short-run, and the changes in copper supply are basically slow, characterized by long adjustment periods. Hence, wide swings in demand over the business cycle in industrial countries, combined with speculative activity in the very short-run on the two organized commodity exchanges, have contributed to the volatility of copper prices internationally.

Generally speaking, the domestic primary producers have tended to change their prices only slowly and not by the magnitude often experienced by the LME price. As a result, the producers' prices have generally remained well below LME prices during periods of strong-demand and above LME prices during periods of weak demand. In other words, there has existed a two-price system for refined copper in the postwar period which was characterized by periods of wide divergence between the outside market price for copper (i.e., the LME price) and the domestic producers' price A combination of factors appears to have had substantial restraining influence on the pricing decisions of the domestic primary producers which resulted in the two-price system. These factors include the actual (as well as the expected) threat of long-run substitution in favor of aluminum, some competition from secondary producers, the apprehension that domestic customers might shift to overseas suppliers if the domestic producers' price remained above the LME price over a prolonged period, the presence of United States government stockpiles, and the threat of governmental intervention (e.g., price controls).

d. Financial Performance

In the past decade, the United States copper industry has experienced modest growth in sales, low return on invested capital, eroding profit margins and higher debt, reflecting the combined pressure of inflation, higher cost of capital, increased capital requirements for environmental control and the worst recession during the postwar period.

Overall profitability for the copper producers, in terms of operating margin on sales, declined from about 23 percent in 1967 to 19 percent in 1974. Over the same period, profit margins for large industrial companies and manufacturers in general was rather stable. In terms of after-tax return on stockholders' equity, copper producers have shown a

rate of return equal to the Federal Trade Commission (FTC) average for all manufacturing. However, the copper industry has been characterized by much greater volatility in its rate of return. This, in turn, stems from the cyclicality of the industry and fluctuations in copper prices.

Capital expenditures by most companies increased sharply in recent years. A significant portion (i.e., about 25 percent) of total industry capital expenditures over the period 1972-1975 has been for pollution abatement, mostly associated with SO_2 control at smelters. About 60 percent of the total represents investment in mining and milling capacity.

With capital expenditures increasing faster than internal cash generation (from earnings, depreciation, and deferred taxes), the cash-flow position of the companies has deteriorated. Consequently, there has occurred in recent years a sharp increase in external financing. Over the last five years, overall debt has approximately doubled, while equity has increased insignificantly. Indeed, some companies are believed to have temporarily reached prudent limits to debt in their capital structure and await higher earnings and stock prices to restore balance and financing flexibility.

F. LIMITS OF ANALYSIS

The objective of this study has been to assess the economic impact of the Clean Air Act Amendments of 1970 and 1977 and the Federal Water Pollution Control Act Amendments of 1972, as described above. Other environmental regulations, including those associated with occupational safety and health, have not been considered in this study.

The computerized econometric simulation modeling approach employed in this study focuses on the domestic copper industry and deals less comprehensively with developments in the rest-of-the-world. For the latter, the model relies on inputs (e.g., LME copper prices) based on analyses of economic growth in the other industrial countries, costs of production abroad, and mine capacity expansion in key copper exporting countries. A comprehensive worldwide modeling approach was contemplated but dropped, in view of resource constraints and competing priorities.

Over the next five-to-ten years, stagnant economic conditions or slow economic growth worldwide, and low LME copper prices, would represent a sharp and persistent reversal of the basic conditions that have prevailed during most of the postwar period. The econometrically estimated equations in the model reflect the prevalent postwar conditions. Hence, a sharp break with these postwar trends results in the model not yielding "strictly" convergent (i.e., mathematically perfectly consistent) solutions. That is, the model does not perform as well under such an unusual situation, which would represent a prolonged state of downturn for the domestic copper industry. From this we conclude

that the domestic copper industry would be severely hurt under such pessimistic assumptions--a conclusion that would be intuitively apparent without the aid of a model.

This study has not examined the cost-effectiveness of the present set of environmental regulations. Such an investigation would identify the socially least-cost environmental control approaches, given the present regulations, assuming that national economic benefits emanating from such regulations are known or accepted at face value. Accordingly, little or no analysis of alternative approaches to pollution control has been performed in this study.

Further, no attempt has been made to quantify the incremental national economic benefits and costs associated with the present set of regulations or to quantify the benefit-cost gradients associated with alternative combinations of regulatory strategies. Such an investigation would have as its purpose the quantification of the national benefit-cost tradeoffs to choose socially optimal environmental control policies.

NOTES

1. Other studies in this series include petroleum refining, iron and steel, pulp and paper, capital markets, electric utilities, foundries, and others.

2. In most cases, local regulations and standards are such that Federal standards are controlling. An exception is the set of standards of the Puget Sound Air Pollution Control Agency which affects the Tacoma smelter.

3. Strong streams are defined as those containing over 4-5 percent SO_2.